

# Modifications to the Standard Sit-and-Reach Flexibility Protocol

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**Objective:** To present several modifications of the standard sit-and-reach protocol.

**Background:** Many exercises designed to increase strength and aerobic capacity tend to decrease the flexibility of the erector spinae and hamstrings musculature. Less-than-ideal flexibility in these soft tissues may increase the risk of injury during training, competition, or activities of daily living. The most widely used measures of flexibility have been either the stand-and-reach or the sit-and-reach, but both are limited to a single measure.

**Description:** Using the new multitest flexometer, we were able to take 6 flexibility measures beyond the stand-and-reach

test: standard active sit-and-reach, standard passive sit-and-reach, modified active sit-and-reach with external rotators slackened, modified passive sit-and-reach with external rotators slackened, modified active sit-and-reach with the hamstrings, gastrocnemii, and external rotators slackened, and modified passive sit-and-reach with the hamstrings, gastrocnemii, and external rotators slackened.

**Clinical Advantages:** This modified sit-and-reach protocol allows the indirect assessment of the influence of the 4 major muscle groups that affect sit-and-reach scores: erector spinae, hip rotators, hamstrings, and gastrocnemii.

**Key Words:** assessment, fitness testing, stretching

It is generally accepted that there are several components to health-related or sport-specific fitness and that the significance of each component varies depending on the activity or sport involved. In recent years, individuals wanting to promote health and well-being have focused on aerobic fitness and strength development, whereas those pursuing excellence in sport focus on all aspects of training. When practiced intelligently, strength and aerobic conditioning result in marked improvements in these fitness parameters. However, many exercises designed to increase strength and aerobic capacity tend to reduce the flexibility of the erector spinae and hamstrings musculature.<sup>1</sup> Less-than-ideal flexibility in these soft tissues may increase the likelihood of injury during a training session, competition, or participation in daily physical activities.<sup>2,3</sup>

## RATIONALE FOR MODIFICATIONS

Testing the combined flexibility of the erector spinae and hamstrings musculature has been an integral part of fitness and sport assessment for many decades. The most common and widely used measure of flexibility has been the sit-and-reach test. This technique has been used extensively in exercise science laboratories, physical education classes, and commercial fitness centers. In these settings, the typical device used to

test this parameter is a flexometer, which is an apparatus that indirectly tests flexibility; many versions have been developed. Most involve a sit-and-reach box with a long scale attached at the top. The scale is marked off in centimeters and inches. A sliding block is attached to the scale, which is pushed by the athlete being tested. Experts agree that both stand-and-reach<sup>4</sup> and sit-and-reach<sup>5</sup> tests have been used extensively as indirect measures to simultaneously assess hamstring and low back flexibility. Each has advantages and disadvantages.

It is interesting to note that the literature does not contain information about the influence on sit-and-reach of either the gastrocnemii or the external rotators of the hip. Laboratory evaluations of kinesiology students and human cadavers have confirmed the influence of other muscle groups.<sup>6</sup> For example, scores using the stand-and-reach are more highly correlated with the Leighton flexometer than are scores using the sit-and-reach.<sup>7</sup> However, while in the sitting position, the performer is able to maintain full extension of the knees and cannot tilt or rotate the pelvis.<sup>8</sup> It has been suggested that scores obtained from both the stand-and-reach and the sit-and-reach are confounded by trunk and limb lengths.<sup>9,10</sup> Broer and Galles<sup>9</sup> have questioned the validity of the sit-and-reach test, suggesting that there is an advantage for an individual with a long trunk, long arms, and short legs. However, a recent study has not confirmed this claim.<sup>1</sup> Both standard techniques (stand-and-reach and sit-and-reach) are limited to a single measure. Neither has an established protocol that allows the measurement of passive range of motion (ROM), nor do they permit a separate assessment of the 4 muscle groups involved.

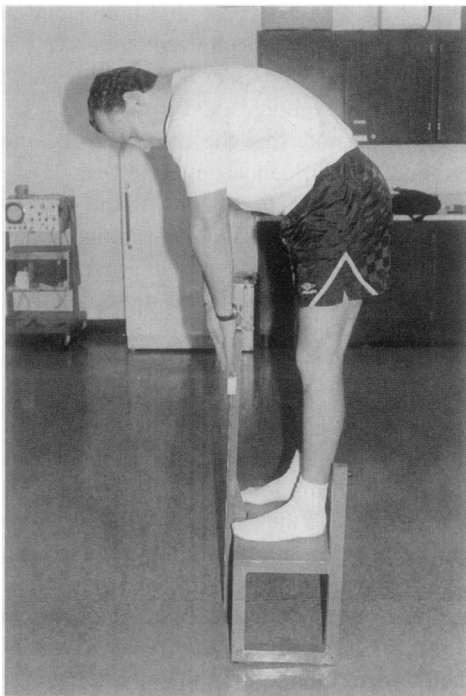
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With the above in mind, our purpose was to present several modifications of the standard sit-and-reach protocol that permit an indirect assessment of the influence of the 4 major muscle groups that affect sit-and-reach scores.

## DESCRIPTION OF DEVICE

In an attempt to indirectly assess the influence of the 4 major muscle groups that affect sit-and-reach scores, a new device called the multitest flexometer (MTF) and several new protocols have been developed. The MTF consists of a foot-support platform, frame, and measuring device. The feet of the subject are placed on (stand-and-reach) (Figure 1) or against (sit-and-reach) the foot-support platform during testing. The foot-support platform is a standard steel plate. The frame of the MTF is constructed of welded beams of steel and can be fastened to the floor via 4 suction cups. The MTF is unique in that it needs no modifications to prepare it for any of the testing procedures. Two customized steel hinge joints allow the MTF to pivot into either the stand-and-reach or sit-and-reach testing position.

The measuring platform is a standard steel plate supporting 2 scales (metric and British). A block moves easily along the length of the scales and permits easy readings of obtained scores. The overall weight of the MTF is less than 15 kg (approximately 30 lb), and it is easy to transport. A board that fastens to the MTF is included for subjects to sit on. The board also has a linear scale in order to record the position of the coccyx during the long-sitting position and the position for tests in which the subject moves toward the platform.



**Figure 1.** The MTF in the stand-and-reach position while the subject performs an active stretch.

## DESCRIPTION OF TESTS

Both the stand-and-reach and the sit-and-reach tests are designed to measure the ROM of the muscle and connective tissue structures involved in these movements. All tests involve a slow, gradual flexion of the lumbar and thoracic regions of the trunk. There is some anterior pelvic tilt, full scapular elevation, and upward rotation, flexion, and horizontal adduction of both shoulder joints with the elbows, wrists, and fingers extended.

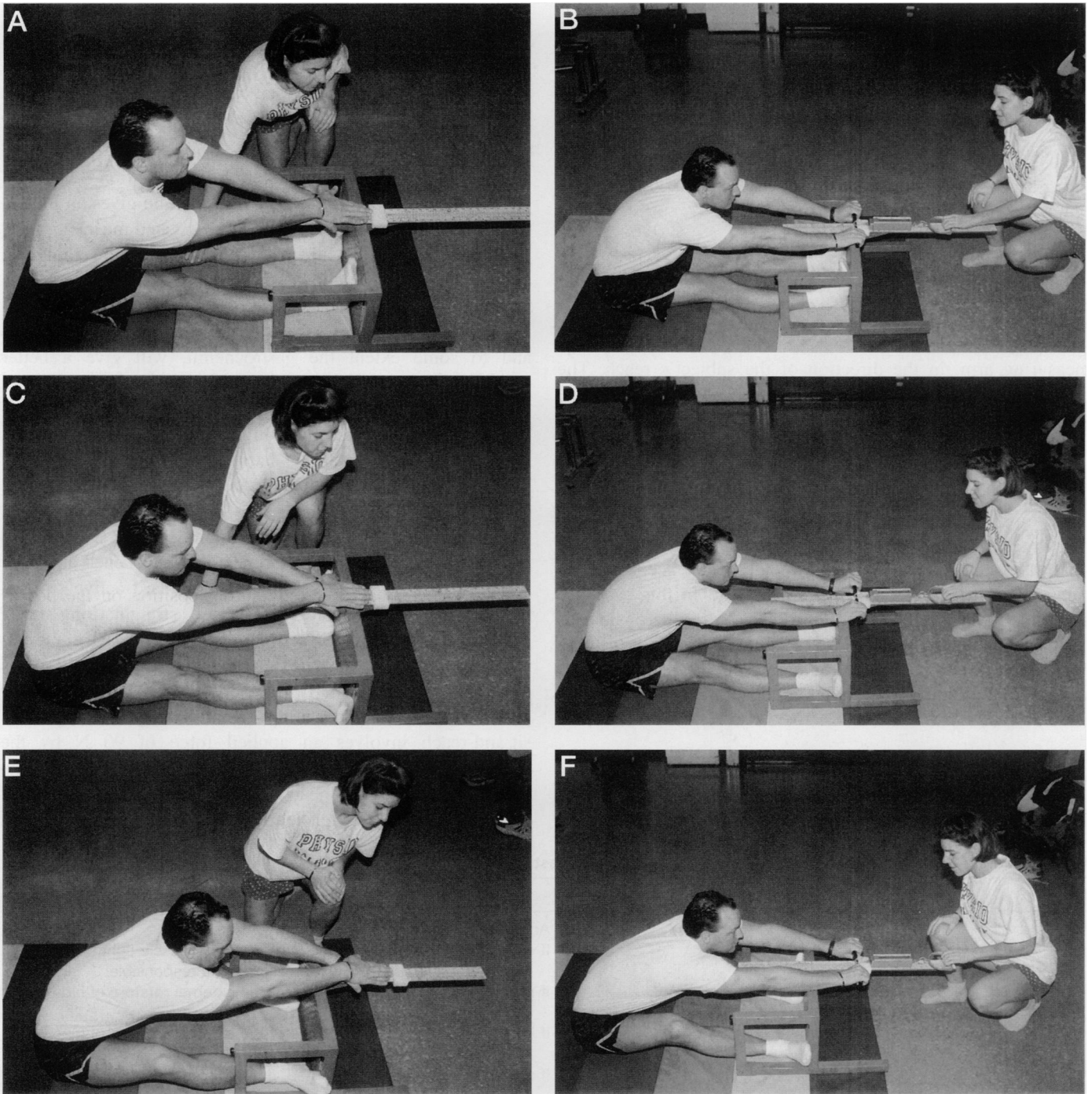
The MTF allows for 6 additional flexibility measures beyond the standard or typical stand-and-reach test: 1) standard active sit-and-reach, with gastrocnemii, hamstrings, external rotators of the hips, and erector spinae in lengthened position (SRa; Figure 2A); 2) standard passive sit-and-reach, as above, with an external force added (90 N used in our studies) (SRp; Figure 2B); 3) modified active sit-and-reach with external rotators slackened (MSR<sup>1</sup>a; Figure 2C); 4) modified passive sit-and-reach with external rotators slackened (MSR<sup>1</sup>p; Figure 2D); 5) modified active sit-and-reach with the hamstrings, gastrocnemii, and external rotators slackened (MSR<sup>2</sup>a; Figure 2E); and 6) modified passive sit-and-reach with the hamstrings, gastrocnemii, and external rotators slackened (MSR<sup>2</sup>p; Figure 2F).

### SRa

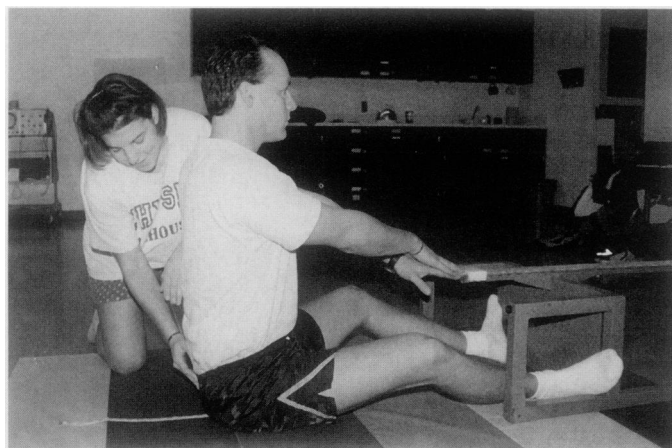
The subject assumes a long-sitting position on the board. The subject keeps the knees fully extended and feet dorsiflexed and positioned flat against the foot-support platform. The sitting distance (position of coccyx) from the MTF is recorded (Figure 3). The toes are even with the front edge of the foot-support platform. The fingertips are placed together, one on top of the other and adjacent to the block that lies along the scale. The subject begins the test by slowly and concentrically contracting the hip flexors and abdominals, bringing the body to the pain-free limit through slow, active concentric contractions. The final position is held with an isometric contraction (2 seconds), and the measurement is taken (the score is the point reached by that part of the block touching the fingers at the completion of movement). During this process, the posterior trunk and posterior shoulder girdle musculature are slowly lengthened, while the knees remain fully extended. The subject's hands move the block along the scale until the movement is terminated because the subject can go no farther.

### SRp

During the SRp test, a gentle external force is applied by the instructor. This assistance is provided through a tensiometer attached to a nylon rope grasped in the hands of the subject. The force is applied when the subject reaches the end of his or her maximum active range. Depending on the size and condition of the person being tested, 90 N may be used. The tensiometer is held by the instructor, who initiates a low-intensity pull on the tensiometer along the plane of the



**Figure 2.** A, The multitest flexometer (MTF) in the sit-and-reach position while the subject performs an active stretch (SRa). B, The MTF in the sit-and-reach position while the subject is assisted in performing a passive stretch (SRp). C, The MTF in the sit-and-reach position while the subject performs an active stretch with the external rotators slackened (MSR¹a). D, The MTF in the sit-and-reach position while the subject is assisted in performing a passive stretch with the external rotators slackened (MSR¹p). E, The MTF in the sit-and-reach position while the subject performs an active stretch with the hamstrings, gastrocnemii, and external rotators slackened (MSR²a). F, The MTF in the sit-and-reach position while the subject is assisted in performing a passive sit-and-reach with the hamstrings, gastrocnemii, and external rotators slackened (MSR²p).



**Figure 3. Instructor measuring the distance during reposition in the MSR<sup>2</sup> test. Note the landmark (coccyx) and the floor scale.**

measuring arm, in the direction of the subject's reach. The instructor initiates a slow build-up to 90 N of force or until the subject experiences any degree of discomfort. If discomfort is felt by the subject, tension is immediately decreased.

### MSR<sup>1a</sup>

The subject initially performs a slow, active sit-and-reach forward stretch, identical to that of the SRa, except that the subject has made a lower limb adjustment. In this case, the subject externally rotates both hip joints. After the position is assumed, normal test procedure is followed. When measuring MSR<sup>1p</sup>, the same procedures as above (ie, MSR<sup>1a</sup>) are used, with the addition of the external application of forces.

### MSR<sup>2a</sup>

In the MSR<sup>2a</sup>, the same procedures for standard active and passive measurements are followed. However, from the stan-

dard straight-leg, sit-and-reach position, subjects externally rotate and flex both hip joints and flex the knees to 145° (internal angle) before measurement. During the MSR<sup>2p</sup> test, the subject is positioned in the identical posture with the same movement as in the SRp and MSR<sup>1p</sup> tests. A gradual force is applied during the test. The instructor must measure the position of the coccyx at the long-sitting position on the floor scale provided with the flexometer. That distance is subtracted from the scores on the 2 final measures to account for the moving up of the body to assume the test position (Figure 3).

SRa is the standard flexibility measure and gives an indication of the combined effects of all investigated muscle groups. Tightness in any or all may contribute to the limits of movements. MSR<sup>1a</sup> allows the testing of forward flexion without the undue influence of the external rotators of the hips. MSR<sup>2a</sup>, by "slackening" the external rotators and hamstrings and to some extent the gastrocnemii, will give a better indication of the erector spinae group's elasticity.

These positional changes help to isolate the relative contributions to sit-and-reach flexibility measurements of the back musculature, hip rotators, hamstrings, and gastrocnemii (Table). Since the feet are both dorsiflexed and the knees are extended, the gastrocnemii provide some limitation in the SRa, SRp, MSR<sup>1a</sup>, and MSR<sup>1p</sup> tests. In the MSR<sup>2a</sup> and MSR<sup>2p</sup> tests, the hamstrings and gastrocnemii are slackened and have less influence on these measures. A standard active sit-and-reach is done with the legs completely straight (long-sitting position). The difference between active and passive sit-and-reach is the final trunk-flexion position. (Trunk flexion as measured in SR and derivatives does involve some anterior pelvic tilt via movement at the lumbosacral joint.) A passive sit-and-reach involves an applied force of 90 N by the instructor while the subject performs the sit-and-reach. The instructor pulls the subject via a hand grip-to-scale-to-hand grip hook-up (cable tensiometer). The SRp, MSR<sup>1p</sup>, and

### Musculoskeletal Limitations to ROM\* During the Sit-and-Reach Tests

Test†	Muscle Groups Assessed	Interpretation‡
SRa	All 4	Any or all of the 4 groups can limit ROM achieved. If external force results in some improvement, muscle tightness, rather than abdominal and hip flexor weakness, is responsible.
SRp	All 4	
MSR <sup>1a</sup>	Release of external rotators	If improvement is noted, tightness of the external rotators of hips would have been a limiting factor in SRa.
MSR <sup>1p</sup>	Release of external rotators	If improvement is noted, tightness of the external rotators of hips would have been a limiting factor in SRp.
MSR <sup>2a</sup>	Release of external rotators, hamstrings, and gastrocnemii	If significant improvement is noted, the hamstrings (and gastrocnemii to a lesser extent) would have been a significant factor in SRa, SRp, MSR <sup>1a</sup> , and MSR <sup>1p</sup> .
MSR <sup>2p</sup>	Release of external rotators, hamstrings, and gastrocnemii	If significant improvement is noted, the hamstrings (and gastrocnemii to a lesser extent) would have been a significant factor in SRa, SRp, MSR <sup>1a</sup> , and MSR <sup>1p</sup> .

\* ROM, range of motion.

† SRa, Standard active sit-and-reach test; SRp, standard passive sit-and-reach test; MSR<sup>1a</sup>, modified active sit-and-reach test with external rotators slackened; MSR<sup>1p</sup>, modified passive sit-and-reach test with external rotators slackened; MSR<sup>2a</sup>, modified active sit-and-reach test with the hamstrings, gastrocnemii, and external rotators slackened; MSR<sup>2p</sup>, modified passive sit-and-reach test with the hamstrings, gastrocnemii, and external rotators slackened.

‡ Soft tissue contact between the abdomen and thighs can limit ROM. However, the interpretation given assumes no such contact.

MSR<sup>2p</sup> tests are used only when passive measures are needed. The indications and precautions (eg, pain and involuntary muscle guarding) regarding passive stretching must be considered on an individual basis before application of this technique. Correct positioning of the athlete and instructor and proper execution of the stretch must be strictly followed.

There are several advantages with regard to testing flexibility with the MTF and the proposed sit-and-reach modifications: 1) the MTF is a simple apparatus to build; 2) it is simple to administer the test and view the scores; 3) it is simple for the athlete to follow instructions; 4) many athletes can be tested in a short period of time; and 5) normative data exist for the standard sit-and-reach and can be developed for all these modifications. The disadvantages include the following: 1) it is an indirect test; 2) anthropometric proportions of the athlete can greatly influence the results; and 3) the test is neither joint specific nor as accurate as other devices (eg, Leighton goniometer).

We are currently testing the MTF with a variety of individuals, from elite athletes and dancers to the elderly. To this point, our subjects have found the apparatus easy to use, and we have found the information from the tests useful. However, all testing should be supervised, and all passive testing should be administered by a qualified instructor only to those individuals without contraindications. With the MTF, both the conventional stand-and-reach and sit-and-reach can be self-administered, and standard norms for all age groups and both sexes can be used for comparisons. The tests are safe and can be performed in a short period of time.

The sit-and-reach test and its modifications can be used by the athletic trainer as an objective ROM assessment tool for specific muscle groups. The passive modifications can add information about the mobility of inert tissues that is specifically related to the function of the sit-and-reach test. In

addition, it can assist the athletic trainer in determining whether manual therapy, soft tissue mobilization, or joint mobilization are appropriate therapeutic requirements to increase mobility and, if so, which techniques would be most beneficial (eg, muscle energy, active exercise, passive stretch, or massage).

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